THE OPTIMIZATION OF A BALANCE CASSAVA DISTRIBUTION IN ORDER TO SUPPORT FOOD SECURITY IN EAST JAVA[1]

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Abstract

The transportation theory is divided into three categories that are the special transportation, public transportation and post-optimal transportation. If those transportations are applied to the distribution of cassava in East Java, they will produce a wide variety of policies that can be selected. A good choice is an optimal ad balanced policy. An optimal indicator of this theory is the minimization of transportation costs. This indicator appears when analyze the data through the ABQM program with various options that can be taken by a manager. The best recommendation obviously has become the first priority and the recommendation in this research is based on mathematical economics calculation. However, this study still has a weakness related to social or other considerations. Therefore, it is necessary to conduct further research.

Keywords: Optimization, distribution, cassava, food security

A. INTRODUCTION

Cassava (*Manihot utilisima* sp.) is one of the substitute commodities for rice. This commodity has a great market potential indicated by various non-rice food made from it. This commodity, sometimes, consumed directly either boiled or fried. The result of early survey showed that the demand of this commodity is high since the overwhelming development of food stalls that sales fried food (*gorengan* in javanese language) with cassava as one of the raw material.

Every seller requires about 20-35 kg of cassava with product diversification of four types of fast food, and it can be sold in 4 – 5 hours. This situation can be found in urban areas such as Surabaya, Madiun, Pasuruan, Mojokerto and other cities. This can be used as an indicator of potential demand on cassava, and other by-products made from cassava such as cassava *tapai* (sweet cake made from fermented cassava), tapioca, cassava cake, and many

* Paper presented at the International Conference on Political Economy of Trade Liberalization in Developing East Asia: Sustainability, Governance, and the Role of Small Business. University of Brawijaya, Malang – Indonesia, November 24-25, 2011

others. A new problem will emerge for fast food producers who use cassava as their raw material and this will be heavier if the productivity of cassava farmers are decreasing.

Currently, the regional average production of cassava in East Java is 159,48 kw/ha. The areas of production center are in Kediri and Banyuwangi with the average production of 191,10 and 193,21 kw/ha, respectively. Urban areas with cassava production on yard are Kediri, Malang, Surabaya and Batu with average production of 144.43 kw/ha, 138.76 kw/ha, 145.00 kw/ha, 133.60 kw/ha, respectively.

A low production (*supply*) of cassava and an increasing demand on the product resulting in an excess demand. Therefore, it will be helpful for the producers (*economic agents*) if policies are applied for the distribution of product from central production region to shortage region.

This imbalance between supply and demand is the main reason for conducting this research. The important position of this research is an efficient, effective, ongoing and integrative distribution of commodities from excess production region to shortage region. It means that distribution is conducted by considering alternatives of product delivery that well- and proper-coordinated to avoid overlapping distribution. It can be overcome by conducting a balance-distribution optimization analysis.

An optimal and balance result can be achieved using transportation and location theories approach. Transportation theory is used in order to find the model of alternative policy for practitioners' or economic agents' interest. The theories used in this approach are North West Corner, Stepping Stone, Degeracy, Minimization Cost, Vogel's Approximation (VA), Modified Distribution and Transshipment that can be utilized as a basis for science development.

B. URGENCY FOR RESEARCH

Focus of the problem in this research is in East Java, Bureau of Statistic states that since 2004 there has been an imbalance cassava production between the production areas and the needed area. The indication is that in each producer of cassava agroindustry ("*gorengan*" food stall) is able to spent about 20-35 kg of cassava in 4 – 5 hours. It can be found in urban areas in East Java – whereas, only several urban areas that produced cassava which are Kediri, Malang, Surabaya and Batu by utilizing wastelands and yards.

Therefore, the optimization of a balance product-distribution is conducted on scopes: (i) optimization on capacity of distributed cassava and its distribution cost from areas with excess production to shortage areas; (ii) optimization of cassava distribution in "possible" candidate areas that also will detect "impossible" candidate areas to distribute cassava; (iii) optimization of cassava distribution in areas if stocks and needs are both depleted; (iv) optimization of distribution by means of least cost minimization as a basis of consideration in cassava distribution in an area; (v) optimization by means of "preventing" the possibility of overlooking potential areas for distribution; (vi) optimization by distributing cassava from excess production areas to shortage areas, but it does not shows which areas that cannot be the destination for cassava distribution; (vii) optimization in order to look for balance solutions inter-area.

Some assumptions in this research were (i) areas of cassava production center are willing to distribute their products to shortage areas; (ii) destination areas for cassava distribution do not have any barriers for distribution such as "Lapindo" mudflow, landslide, bad weather, and others; (iii) easy access in transportation, whether by land, air or sea transportations.

This research will be used as a basis for policy formulation on optimal and balanced cassava distribution from excess production area to some areas with excess demand, and in turn, this balance of optimization will create an integrative food security inter-regional in East Java.

Based on aforementioned contradictions about the product, it can be identified some specific problems as follow:

1. What is the level of distribution optimization from areas with excess production to shortage areas?
2. How much is the optimization of cassava distribution in desirable potential areas or "possible" candidates and impossible candidates?
3. How big is the optimization of cassava distribution in the areas if stocks and needs are both depleted?
4. How big is the optimization of cassava distribution in the areas by means of minimization of the least distribution cost?
5. How is the optimization by means of "preventing" the possibility of overlooking potential areas for distribution?
6. How is the resulted distribution optimization in areas which not supposed to be the destination of cassava distribution?
7. How is the distribution optimization in order to find solution for inter-area balance?

C. RESEARCH OBJECTIVES

This study aimed to:

1. Detect the optimization level of the capacity of distributed cassava and its distribution cost from areas with excess production (excess supply) to shortage areas (excess demand).
2. Analyze the optimization of cassava distribution in desirable 'potential' areas (possible candidates) that also will detect "impossible" candidate areas to distribute cassava.
3. Analyze the optimization of cassava distribution in the areas if stocks and needs are both depleted.
4. Analyze the optimization of distribution by minimization of the least transportation cost.
5. Detect the optimization by means of "preventing" the possibility of overlooking potential areas for distribution.
6. Analyze the resulted distribution optimization in areas which not supposed to be the destination of cassava distribution.
7. Analyze the distribution optimization in order to find solution for inter-area balance.

D. BASIS THEORY

D.1. TRANSPORTATION THEORY

Optimization of cassava distribution can be done using transportation theory that approached through the sophisticated models including the North West Corner Method, Stepping Stone, Degeracy, Minimization Cost, Vogel's Approximation (VA), Modified Distribution and Transshipment. From those models, an optimal distribution will be conducted since the availability of economic resources is scarce because it not always available in every place on earth.

Besides, the primary economic activities – production, consumption and distribution – to process those economic resources are cannot always be done in the same location; therefore, people in their economic activities often faced by problem of distance gap of geographical location.

This distance gap problem has prompted the development of transportation as one of key factors in human life and particularly in economic development. The role of transportation is becoming important to interconnecting areas of raw material sources, production areas, marketing areas and resident areas/consumers housing. Therefore, transportation should function as a bridge that connecting producers and consumers by eliminating the distance (gap) between them, either "time distance" or "location/geographical distance" (*Benson and Whitehead, 1975* in Hamze, 2003).

Related to the efforts to create a balance between supply and demand for transportation services, some theoretical views are explained as follows: (i) transportation is a movement from one place (origin place) to another (destination); (ii) the transportation services provided for public are the result of transportation system management; (iii) the demand for transportation services is always follow the activities of all economic sectors; (iv) related to the supply, a consideration should be given to the nature of transportation facilities which is different from other commodities since it cannot be stocked or serviced regularly; (v) transportation is not the goal, but it is a suggestion to facilitate the achievement of objectives; (vi) for urban areas, transportation plays a significant role since one of characteristics of a good city is related to its transportation condition; (vii) transportation and land use are inseparable, like two sides of a coin; (viii) transportation activities in form of vehicle traffic is always supported by one of three types of transportation mode either land, air or water transportations; from the transportation technique science points of view, Morlok and Hamzen (2003) state that transportation is a combination of technical, engineering, planning, regional and economic sciences.

D.2 LOCATION THEORY

The entry of "location theory" into the discussion domain of economic science has went through a long history since Von Thumen developed a "theory of location area” in 1830 and later, it established by Walter Isard by introducing a complete location theory in 1952. Since then, the opportunities are open to improved economic science by taken into account on spatial dimension.

It is not exaggerate that in the production economic has managed to explain “what”, “how much”, “how”, “who”, and “when” questions. However, it does not questioned about “where” the production activities are held. In other words, a variety of economic analysis is in the framework of space less world. Whereas, it is clear that any economic analysis, placed on the situation of wonderland of no dimensions, is way out of reality. This statement aimed as a note to shows the direction of theoretical research to improve economic science, especially the one that taken into account spatial dimension and as the beginning of discussion on location theory or “space” (Iwan Jaya Azis in Marsudi Djojodipuro, 1994, 31).

D.3 THE RELEVANCE OF LOCATION, TRANSPORTATION AND DISTRIBUTION

The importance of transportation for human life can be explained as follow: (1) human activities in meeting their daily needs can be identified into three main categories of economic activities, which are: (a) production activities, (b) consumption activities, and (c) trade and commerce; and (2) the reality indicates that economic resources are available only in some places in the world, and all economic activities do not always conducted in a location simultaneously. In other words, a geographical distance gap is exists between production factors, economic resources and economic activities. In overcoming the geographical distance a new need arose in human life which is the need to “move” from one location to another. This need called transportation that provided both by oneself and other people. Therefore, the transportation problem in human life is a problem that continuously occurs to move (distribute) goods from one location to another.

Cassava distribution that will be done in this research is aimed to help overcoming cassava accumulation in one area. The application, indeed, will be submitted to market mechanism since the responsibility of distribution is not only on government hand but also on market agents. The government, however, has a role as a mediator in supporting the smoothness of distribution for the establishment of optimal and balanced condition.

E. RESEARCH METHOD

Cassava distribution with transportation and location theory approaches play role and function as an interface medium that able to eliminate the distance gap between locations, by moving people or goods from one place to another. In other words, transportation has a function as a “bridge” connecting or distributing (a) source location to producer location; (b) producer location to market location; and (c) producer location to consumer location, namely by eliminating distance gap so-called “geographical distance” or “spatial distance” between the two locations.

The research was conducted in East Java and the details of data are (i) production data, (2) data of market location, and (3) data of transportation cost. Those data are expected to represent and answer the need of balance-distribution optimization.

The analysis of optimization of a balance cassava distribution in this research conducted using seven methods approach, namely:

1. Northwest Corner Method
2. Stepping Stone Method
3. Degeneracy Method
4. Minimization Cost Method
5. Vogel's Approximation Method (VAM)
6. Modified Distribution Method
7. TransshipmentMethod

Table 1. The Aims and Analysis Models

The aims	Analysis models
	The special transportation
1. The distribution from excess supply to excess demand	1. North west corner method (NW/CM)
2. The optimal with minimiz. cost	2. Minimization cost method (MCM)
3. To prevent: the region stepping	3. Vogel's Approximation m. (VAM)
4. The balance of optimization	The general transportation 4. Transshipment Method (TM)
5. The optimization with possible candidate and impossible candidate	The analysis post-optimization 5. Stepping stone method (SSM)
6. 'no' necessity condition	6. Modified distribution meth. (MODI)
7. The development of science (simuls)	7. The degeracy method

F. RESULTS

F.1. THE OPTIMAL LEVEL OF CASSAVA DISTRIBUTION FROM THE EXCESS PRODUCTION (EXCESS SUPPLY) AREA TO THE SHORTAGE AREA (EXCESS DEMAND)

North West corner method (NW/CM) was used to answer the first objective of this research. The result of NWCM analysis, summarized in Table 1, shows that the condition between areas with excess cassava production and destination area indicates an optimal condition based on the finished amount of distributed cassava (sources = 0.00, see Table 1). Based on the result of NWCM analysis, there are several alternatives in the cassava distribution from excess production regency to shortage regency, as follow:

1. The destination regencies of 1 – 7, Sidoarjo (D_1), Jember (D_2), Gresik (D_3), Banyuwangi (D_4), Jombang (D_5), and Mojokerto (D_6) regencies, show an optimal condition. It means that the nearest regencies from those regencies have been able to fulfill the shortage in those six regencies. The basic of order 1 to 7 is the number of cassava's requirement; the higher the number, the

lower the requirement for cassava in the regency. Those six regencies are optimally fulfilled from the origin regencies S_1, which consist of Pasuruan, Bangkalan, Malang and Probolinggo regencies.

Table 1. Results of NWCM Analysis (Program Output, Initial Solution by NWCM)

Regions	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	S_i
S1	153914	200521	103233	132433	111088	86874	15235	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
S2	0.0	0.0	0.0	0.0	0.0	0.0	87502	109171	92459	5383	72153	88547	125421	61106	41333
S3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	637733
S4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	304601
S5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	342104
S6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	300501
S7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	332315
S8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	218342
S9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	393891
S10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	165565
S11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	468646
S12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	304621
S13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480581
S14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	165565
D_i	153913	200521	103233	132433	111087	86874	102737	109171	92459	53831	72153	88547	125421	61106	4155798

2. The destination regencies 8 – 14, Lamongan (D_7), Bojonegoro (D_8), Blitar (D_9), Situbondo (D_{10}), Pamekasan (D_{11}), Lumajang (D_{12}), Kediri (D_{13}) and Bondowoso (D_{14}) regencies, are regencies that still unable to be fulfilled from region S_1. The optimal condition in the regencies 8 -14 are reached by the fulfillment from destination area of S_2 (Probolinggo, Pasuruan and Malang regencies) with the remaining delivery of 41.333 ton (sources = 41.333; see Table 1); except for Lamongan (D_7) regency that can be fulfilled from destination regency 1 (S_1) and/or destination regency 2 (S_2).
3. From those two alternatives, managers are faced by two choices – which decision that going to be taken will depend on the smallest possible risk they faced in the implementation of the distribution.

The Northwest Corner Method was introduced by Charnes and Cooper, and later developed by Danzig. This analysis does not show whether the recommendation submitted is optimal or not? The planners surely have to look for solutions and alternatives as many as possible before submitting any recommendation. One of tools that can be used is transportation analysis with Modified Distribution Method (MODI) which is developed from NCM analysis.

The above basis of reasonable answer that found using Northwest Corner Method (NCM) may still be far from optimal because cost factors are excluded in the calculation. However, this method is better than the simplex method because it simplify the determination of optimal answer, especially for problems consisting of enormous number of origin (A_i) and destination (J_i). In addition, the answer has been directly an integer without rounding it, as is often done in a simplex way.

From the above analysis, the initial solution is 177.001.100. If this number divided by Rp. 5.000,-, the average of minimum distribution cost is Rp. 3.540,- per ton or km. This result, generally, does not show an optimal condition; therefore, an integration of calculation with MODI model is needed. This model will be discussed under MODI section. If the initial solution turned to optimal solution and shows equal to zero, then, the recommendation indicates an optimal cassava distribution.

F.2. ANALYSIS ON THE OPTIMIZATION OF CASSAVA DISTRIBUTION IN DESIRABLE 'POTENTIAL' AREAS (POSSIBLE CANDIDATES) AND "IMPOSSIBLE" CANDIDATE AREAS TO DISTRIBUTE CASSAVA

The minimization cost method (MCM) was used to answer the second objective. Similar to NWCM, this method is a special transportation analysis tool aimed to optimally distribute cassava with minimum cost (see table of the relevance matrix of aims and analysis model on research method section above).

MC is one of three special transportation models. The model is a little bit different from the northwest corner method which is not considering the cost factor. The analysis results are summarized in Table 2.

Table 2 shows the optimization with minimum cost indicator. The alternative recommendations for cassava shipping to reach the optimal condition are as follow:

1. Sidoarjo regency with the minimum shipping cost will be fulfilled from regency S_2 that consist of Probolinggo, Pasuruan and Malang regencies.
2. The destination regencies of 2 – 5, Jember (D_2), Gresik (D_3), Banyuwangi (D_4), Jombang (D_5), show an optimal condition. It means that the nearest regencies from those regencies are able to fulfill the shortage of those four regencies. Same as the above analysis, the basic of order 1 to 7 is the number of cassava's requirement; the higher the number, the lower the requirement for cassava in the regency. The destination regencies of 2 – 5 has optimally fulfilled from regency S_1 consisting of Pasuruan, Bangkalan, Malang and Probolinggo regencies. In fact, regency S_1 also supplies Bojonegoro (D_8) and Kediri (D_{13}) regencies. If the recommendations are applied, the remaining cassava that available in S_1 is 21.431 ton (sources=21.431; see Table 2).
3. The destination regencies of 6,7,9-12 and 14, Mojokerto (D_6), Lamongan (D_7), Blitar (D_9), Situbondo (D_{10}), Pamekasan (D_{11}), Lumajang (D_{12}) and Bondowoso (D_{14}), are fulfilled from regency S_2. The optimal condition can be met from the fulfillment of destination area S_2 (Probolinggo, Pasuruan and Malang regencies) with the remaining shipping of 19.902 ton (sources= 19.902, see Table 2).
4. From those two alternatives, managers are faced by two choices – which decision that going to be taken will depend on the smallest possible risk they faced in the implementation of the distribution.

Table 2. Minimum Cost Analysis Result (Program Output; Initial Solution by Minimum-Cell-Cost-Method (MC)

Regions	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	S_i
S1	0.0	200521	103233	132433	111088	0.0	0.0	109171	0.0	0.0	0.0	0.0	0.0	0.0	21431
S2	153914	0.0	0.0	0.0	0.0	86874	102737	0.0	92459	5383	72153	88547	125421	61106	19902
S3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	637733
S4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	304601
S5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	342104
S6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	300501
S7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	332315
S8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	218342
S9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	393891
S10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	165565
S11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	468646
S12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	304621
S13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	480581
S14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	165565
D_i	153913	200521	103233	132433	111087	86874	102737	109171	92459	53831	72153	88547	125421	61106	4155798

From the NWCM analysis, the initial solution is 177.001.100. If this number divided by Rp. 5.000,-, the average of minimum distribution cost is Rp. 3.540,- per ton or km. However from the result of MCM analysis and the above alternative recommendations, the initial solution shows zero (0.00) means that the result is optimal.

This optimal result will be proved by MODI analysis that will be discussed in MODI section. If the initial solution turned to optimal solution and shows equal to zero, then, the recommendation shows an optimal cassava distribution. This mathematical analysis can be done as a recommendation from planners to the company or government to be applied with the least cost. Obviously, planners and mathematicians realized that in field application need to consider the environment conditions, road, traffic, and other factors.

F.3. ANALYSIS ON THE OPTIMIZATION OF CASSAVA DISTRIBUTION IN THE AREAS IF STOCKS AND NEEDS ARE BOTH DEPLETED

Vogel Method was used to answer the third objective. This method was proposed by W.R. Vogel in 1958. The least cost pricing method will raise the possibility of a better cell (regency) elimination since we have to leave rows and columns in accordance with the restrictions. VAM is also similar to NWCM analysis which is a special transportation analysis tool. VAM aimed to describe optimization by means of “preventing” the possibility of overlooking the potential areas for distribution.

Table 3. Analysis results of Vogel Approximation Method (VAM) (Program Output; Initial Solution by VAM Method)

Regions	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	S_i
S1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	803298
S2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	731523
S3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	637733
S4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	304601
S5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	342104
S6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	300501
S7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	332315
S8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	218342
S9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	393891
S10	0.0	165565	99704	132433	111088	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00
S11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	125421	0.0	0.00
S12	0.0	0.0	0.0	0.0	0.0	0.0	102737	109171	92459	0.0	0.0	0.0	0.0	0.0	254
S13	0.0	34956	3529	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72153	88547	0.0	61106	79585
S14	153914	0.0	0.0	0.0	0.0	86874	0.0	0.0	0.0	53831	0.0	0.0	0.0	0.0	11651
D_i	153913	200521	103233	132433	111087	86874	102737	109171	92459	53831	72153	88547	125421	61106	4155798

The Vogel Approximation Method (VAM) is preventing the possibility to overlooking the potential areas for distribution by selecting two lowest prices on a row which are C_{ij} and C_{ir} and then calculate it. Since there are m rows, there will be m number and this number called Vogel number. The same way is applied for each column until there are n numbers which also the difference between two lowest cost prices in each column.

The results above proved that there are opportunities to get more than one or two answers based on the problems faced. If this amount is limited, we can compare one answer against another to reach optimal answer. Thus, the possibility of a better-basic sell discharge will be very small.

The analysis results in Table 3 show that optimization can be achieved only by Vogel process. The indication of the optimal condition is the result of the initial solution that equal to zero (0.00). Thus, the alternative recommendations for cassava shipment that must be applied in order to meet the optimal condition are as follow:

1. Sidoarjo regency (D_1) with the minimum shipping fee, will be fulfilled from regency S_{14} which is Bondowoso regency with the remaining cassava after the shipment to Sidoarjo is 11.651 ton (sources=11.651 – see Table 3).
2. The destination regencies of 2 – 3 (Jember (D_2) and Gresik (D_3) regencies) have optimally fulfilled from origin area – Probolinggo regency (S_{10}) – the optimum condition shown by source=0.00 (see Table 3). However, Jember and Gresik regencies have to be subsidized from other regencies which are Nganjuk, Trenggalek and Tulungagung (S_{13}) regencies. Likewise, S_{13} also

fulfilled the need of Pamekasan (D_{11}), Lumajang (D_{12}) and Bondowoso (D_{14}) regencies.

3. The destination regencies of Banyuwangi (D_4) and Jombang (D_5) have optimally fulfilled from origin area Probolinggo regency (S_{10}) - the optimum condition shown by source=0.00 (see Table 3). In other words, the optimal condition in origin area Probolinggo (S_{10}) is able to supply the nearest regencies D_2 – D_5 which are Jember, Gresik, Banyuwangi and Jombang regencies.
4. Another alternative policy based on Vogel model analysis is that the destination area D_6 which is Mojokerto regency can be fulfilled from Probolinggo regency (S_{14}). Therefore, there are three alternatives of cassava distribution areas for Probolinggo regency which is Mojokerto, Sidoarjo (D_1) and Situbondo (D_{10}) with the shipment of 153,914 ton, 86,874 ton and 53,831 ton, respectively. Of three shipping alternatives – the best choice selected is the shipment from Probolinggo regency (S_{14}) to Sidoarjo regency (D_1) because the remaining cassava after the shipment is at the very least (sources = 11.651) compare to other two regencies, Mojokerto (D_6) and Situbondo (D_{10}) with the remaining cassava after the shipment is 78,691 ton and 111,734 ton, respectively. This situation occurs because in the calculation iteration concern about distributions in other regencies as described in Table 9.
5. The destination regencies of 7, 8, and 9, Lumajang (D_7), Bojonegoro (D_8) and Blitar (D_9), are fulfilled from area S_{12} consisting of Probolinggo and Pasuruan with the remaining availability of 254 ton (sources=254).
6. Whereas, the destination regency that show an optimum condition is D_{13} which is Kediri regency and supplied from regency S_{11} consisting of Sampang, Sumenep and Bangkalan regencies. The optimum condition is reached indicates by sources=0.00 (see Table 3).

F.4. ANALYSIS ON THE DISTRIBUTION OPTIMIZATION BY MINIMIZATION OF THE LEAST TRANSPORTATION COST

The fourth objective of this research is the optimization analysis to find a balance solution between regions using Transshipment method (TM) (note: TM is a method of general transportation analysis) – therefore, it can be said that TM is a summary analysis of three analyses above.

In other words, the TM method is a general model of transportation and it break down into three specific models, NWCM, MC and Vogel. Besides, TM is an analysis to answer the balance of optimization problem. The examples used are generally simple and do not contain extraordinary things. However, in practice (in the research for cassava distribution), the problems are not that simple. In some problems, special circumstances occur that would complicate the use of algorithm such as stepping stone or MODI.

Some of these special circumstances, namely: (i) the imbalance between supply and demand, (ii) the optimal answer can be obtained with more than one patterns, (iii) there are two or more indices (which will be increased) with the same least-negative price; and (iv) degeneracy problems are occur, etc.

Thus, transshipment problem is a general form of transportation model, whereas transportation model is a special form where there are centers of the origin or the original sources, centers of origin destination, and the transshipment points. The transshipment points are either in the centers of origin or centers of destination. In this model, every center can send or receive the flow of goods. It means that there exist a discretion to determine the route for the goods from point i to point j, in addition to the direct route.

How much is the optimization of cassava distribution on desirable potential areas (possible candidates) and impossible candidates.

The basic for transshipment analysis (TM) is the result of NWCM (Table 1), MC (Table 2) and VAM (Table 9) analyses. The analysis results can be explained as follow:

1. Sidoarjo regency (D_1)
   The options for Sidoarjo regency (D_1) are from S_1 (based on NWCM analysis), S_2 (based from MC analysis) and S_{14} (based from VAM analysis). From the initial solution points of view, these solutions are optimum since the zero value is reached; however, the results are temporary in nature since the decision can be made based on MODI analysis which is a post-optimum analysis.
   The cassava shortage in Sidoarjo regency as the first destination (D_1) can be fulfilled from the options outlined in Table 4.
   Table 4. Transshipment Analysis, Balance Analysis for D_1

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_2 = from Pasuruan from Malang from Probolinggo	S_3 = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

   If the results from MODI analysis finally show an optimum solution which is equal to zero – either in NWCM, MC or VAM analyses – the alternative to be selected is the one that show a balance. This balance indicates by the same initial solution. From the above results, the balance is shown by NWCM and MC analyses. Therefore, those analyses are selected alternative, whereas VAM will be the last alternative chosen. VAM is an analysis that aims to look for the possibility of overlooking potential areas. Based on the VAM results, of the four regencies, Probolinggo is the overlooked regency. By overlooked means that is the regency able to supply the shortage regencies?. The answer for the question apparently is yes; in fact, the initial solution is optimal since from its production, Probolinggo is able to completely fulfill its need/shortage.
2. Jember Regency
   Results show the alternative areas that eligible from the NWCM, MC and VAM analysis; it is outlined in Table 5. The shipment variation for VAM analysis is from two sources, which are S_{10} from Probolinggo and S_{13} from

three regencies, Nganjuk, Trenggalek and Tulungagung. The explanation is the same as for D_1.

Table 5. Transshipment Analysis, Balance Analysis for D_2

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{10} = from Probolinggo S_{13} = from Ngajuk from Trenggalek from Tulungagung
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

The initial solution can be interpreted that the advance solutions are still possible using MODI analysis. If the initial solutions do not show zero value, such as the above result of 177001100, it is necessary to look for another iteration calculation to achieve optimal solution.

If the initial solution has shown zero value, then the calculation is sufficient, and if it continues to be calculated the result will be the same. It means that if the initial solution is 0.00, the alternative options will be the analysis results, as shown by VAM analysis in Table 5. Thus, the more iteration calculation conducted, the more policy alternatives are available. Therefore, decision makers have various choices and the decision will be depend on the needs of the companies, producers, managers, or governments as the policy maker.

3. Gresik Regency (D_3)
   The analysis results of the three models above are also summarized in Table 6. The regencies that able to supply cassava are from sources of S_1, S_{10} and S_{13}, the same like in Jember regency.

Table 6. Transshipment Analysis, Balance Analysis for D_3

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{10} = from Probolinggo S_{13} = from Ngajuk from Trenggalek from Tulungagung
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

4. Banyuwangi Regency (D_4)
   The analysis results of the three models above are also summarized in Table 7. The regencies that able to supply cassava are from sources of S_1 and S_{10}.

Table 7. Transshipment Analysis, Balance Analysis for D_4

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{10} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

5. Jombang Regency (D_5)

The analysis results of the three models above are also summarized in Table 8. The regencies that able to supply cassava are from sources of S_1 and S_{10}.

Table 8. Transshipment Analysis, Balance Analysis for D_5

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{10} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

6. Mojokerto Regency (D_6)

The analysis results of the three models above are also summarized in Table 9. The regencies that able to supply cassava are from sources of S_1, S_{12} and S_{14}.

Table 9. Transshipment Analysis, Balance Analysis for D_6

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_2 = from Pasuruan from Malang from Probolinggo	S_{14} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

7. Lamongan Regency (D_7)

The analysis results of the three models above are also summarized in Table 10. The regencies that able to supply cassava are from sources of S_1, S_2, and S_{12}.

Table 10. Transshipment Analysis, Balance Analysis for D_7

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_2 = from Pasuruan from Malang from Probolinggo	S_{12} = from Probolinggo from Pasuruan
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

8. Bojonegoro Regency (D_8)

   The analysis results of the three models above are also summarized in Table 11. The regencies that able to supply cassava are from sources of S_1, S_2, and S_{12}.

Table 11. Transshipment Analysis, Balance Analysis for D_8

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan from Malang from Probolinggo	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{12} = from Probolinggo from Pasuruan
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

9. Blitar Regency (D_9)

   The analysis results of the three models above are also summarized in Table 12. The regencies that able to supply cassava are from sources of S_2 and S_{12}.

Table 12. Transshipment Analysis, Balance Analysis for D_9

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan from Malang from Probolinggo	S_2 = from Pasuruan from Malang from Probolinggo	S_{12} = from Probolinggo from Pasuruan
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

10. Situbondo Regency (D_{10})

    The analysis results of the three models above are also summarized in Table 13. The regencies that able to supply cassava are from sources of S_2 and S_{14}.

Table 13. Transshipment Analysis, Balance Analysis for D_{10}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan from Malang from Probolinggo	S_2 = from Pasuruan from Malang from Probolinggo	S_{14} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

11. Pamekasan Regency (D_{11})

The analysis results of the three models above are also summarized in Table 14. The regencies that able to supply cassava are from sources of S_2 and S_{13}.

Table 14. Transshipment Analysis, Balance Analysis for D_{11}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan from Malang from Probolinggo	S_2 = from Pasuruan from Malang from Probolinggo	S_{13} = from Nganjuk from Trenggalek from Tulungagung
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

12. Lumajang regency (D_{12})

The analysis results of the three models above are also summarized in Table 15. The regencies that able to supply cassava are from sources of S_2 and S_{13}.

Table 15. Transshipment Analysis, Balance Analysis for D_{12}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan from Malang from Probolinggo	S_2 = from Pasuruan from Malang from Probolinggo	S_{13} = from Nganjuk from Trenggalek from Tulungagung
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

13. Kediri regency (D_{13})

The analysis results of the three models above are also summarized in Table 16. The regencies that able to supply cassava are from sources of S_2 and S_{11}.

Table 16. Transshipment Analysis, Balance Analysis for D_{13}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan from Malang from Probolinggo	S_2 = from Pasuruan from Malang from Probolinggo	S_{11} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

14. Bondowoso regency (D_{14})

The analysis result of the three models above is also summarized in Table 17. The regencies that able to supply cassava are from sources of S_2 and S_{13}.

Table 17. Transshipment Analysis, Balance Analysis for D_{14}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan from Malang from Probolinggo	S_1 = from Pasuruan from Malang from Probolinggo	S_{13} = from Nganjuk from Trenggalek from Tulungagung
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

F.5. ANALYSIS ON THE OPTIMIZATION BY MEANS OF "PREVENTING" THE POSSIBILITY OF OVERLOOKING POTENTIAL AREAS FOR DISTRIBUTION

The Stepping Stone Method (SSM), which is the basis of MODI method, is used to answer the fifth objective. There are two alternatives of evaluation procedure on unused squares that going to be directed, namely Stepping Stone Method and Modi Method. If the initial solution for the optimal problem has been obtained, the next step is to determine whether the solution is the best or the least-cost solution. The assessment procedure is related to the investigation against unused squares in the table to indicate whether it is desirable to direct the shipment to one of the unused squares. The purpose of this evaluation is to determine whether a better shipment method from factories to the project can be developed.

SSM analysis is one of the post-optimization analyses. This analysis aims to detect the optimization condition of cassava distribution in the desirable "potential" areas (possible candidates), that will also detect impossible candidates to distribute cassava.

Basis of determination in this analysis is the analysis results in Table 5-9. Based on the SSM philosophy, the shortage regencies can be explained as follow:

1. Sidoarjo regency as the first destination (D_1), it shortage can be fulfilled from options outlined in Table 18.

Table 18. Stepping Stone Analysis (the analysis of post-optimization) for D_1

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan (37) from Bangkalan (51) from Malang (66) from Probolinggo (76)	S_2 = from Pasuruan from Malang from Probolinggo	S_{14} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance from S_i to D_1

The options for Sidoarjo Regency (D_1) are from S_1 (based on NWCM analysis), S_2 (based on MC analysis) and S_{14} (based on VAM analysis). The possible candidate is the one with the nearest distance which is Pasuruan regency with 37 km of distance to Sidoarjo (Sidoarjo-Pasuruan). However, there exist impossible candidate for cassava distribution which is Probolinggo, since the distance is far, 76 km, compare to other regencies.

2. Jember Regency (D_2)

The analysis results show that the eligible alternative areas based on NWCM, MC and VAM analyses are outlined in Table 19. The shipment variation for VAM analysis is from two sources, which are S_{10} from Probolinggo and S_{13} from three regencies, Nganjuk, Trenggalek and Tulungagung. The explanation is the same as for D_1.

Table 19. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_2

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan (137) from Bangkalan (225) from Malang (192) from Probolinggo (96)	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{10} = from Probolinggo S_{13} = from Ngajuk (269) from Trenggalek(334) from Tulungagung(303)
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance from S_i to D_2

The possibility of desirable regency (possible candidate) is the one with the nearest distance which is Jember – Probolinggo with the distance of 96 km. However, there exist impossible candidate for cassava distribution which is regency that located further away, i.e. Trenggalek. Therefore, the recommendation is Jember – Probolinggo.

3. Gresik Regency (D_3)

The analysis results of the three models above are also summarized in Table 20. The regencies that able to supply cassava are from sources of S_1, S_{10} and S_{13}, same as in Jember regency. The recommendation is Gresik – Bangkalan.

Table 20. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_3

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan (78) from Bangkalan (46) from Malang (107) from Probolinggo (117)	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{10} = from Probolinggo S_{13} = from Ngajuk (137) from Trenggalek(204) from Tulungagung(172)
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance from S_i to D_3

Note: Thus, SSM analysis used to give recommendation for previous analyses, NWCM, MC and VAM. However, this recommendation is flexible (conditional or situational), means that the priority will be the nearest distance – if it is impossible, the next nearest distance can be chosen, and so on until the appropriate one is met for the cassava distribution.

4. Banyuwangi Regency (D_4)

The analysis results of the three models above are also summarized in Table 21. The regencies that able to supply cassava are from sources of S_1 and S_{10}.
Table 21. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_4

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan (228) from Bangkalan (316) from Malang (239) from Probolinggo (189)	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{10} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance from S_i to D_4

5. Jombang Regency (D_5)

The analysis results of the three models above are also summarized in Table 22. The regencies that able to supply cassava are from sources of S_1 and S_{10}, the same as in Banyuwangi Regency.

Table 22. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_5

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan (91) from Bangkalan (107) from Malang (119) from Probolinggo (130)	S_1 = from Pasuruan from Bangkalan from Malang from Probolinggo	S_{10} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_5

6. Mojokerto Regency (D_6)

The analysis results of the three models above are also summarized in Table 23. The regencies that able to supply cassava are from sources of S_1, S_2 and S_{14}. The recommendations offered are Pasuruan and Mojokerto, and the impossible area is Probolinggo Regency.

Table 23. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_6

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan (61) from Bangkalan (77) from Malang (86) from Probolinggo (100)	S_2 = from Pasuruan from Malang from Probolinggo	S_{14} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_6

7. Lamongan Regency (D_7)

The analysis results of the three models above are also summarized in Table 24. The regencies that able to supply cassava are from sources of S_1, S_2 and S_{12}. The recommendation in the cassava distribution is Bangkalan – Lamongan.

Table 24. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_7

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_1 = from Pasuruan (105) from Bangkalan (73) from Malang (134) from Probolinggo (144)	S_2 = from Pasuruan from Malang from Probolinggo	S_{12} = from Probolinggo from Pasuruan
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_7

8. Bojonegoro Regency (D_8)

The analysis results of the three models above are also summarized in Table 25. The regencies that able to supply cassava are from sources of S_1, S_2 and S_{12}.

Table 25. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_8

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan (168) from Malang (197) from Probolinggo (207)	S_1 = from Pasuruan from Bangkalan (136) from Malang from Probolinggo	S_{12} = from Probolinggo from Pasuruan
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_8

9. Blitar Regency (D_9)

The analysis results of the three models above are also summarized in Table 26. The regencies that able to supply cassava are from sources of S_2 and S_{12}.

Table 26. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_9

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan (133) from Malang (78) from Probolinggo (172)	S_1 = from Pasuruan from Malang from Probolinggo	S_{12} = from Probolinggo from Pasuruan
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_9

10. Situbondo (D_{10})

The analysis results of the three models above are also summarized in Table 27. The regencies that able to supply cassava are from sources of S_2 and S_{14}.. The recommended regency is Probolinggo – Situbondo with distance of 95 km, and the impossible candidate or the least option is Malang.

Table 27. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_{10}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan (134) from Malang (192) from Probolinggo (95)	S_2 = from Pasuruan from Malang from Probolinggo	S_{14} = from Probolinggo
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_{10}

11. Pamekasan Regency (D_{11})

The analysis results of the three models above are also summarized in Table 28. The regencies that able to supply cassava are from sources of S_2 and S_{13}.

Table 28. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_{11}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan (183) from Malang (212) from Probolinggo (222)	S_2 = from Pasuruan from Malang from Probolinggo	S_{13} = from Ngajuk (242) from Trenggalek(309) from Tulungagung(277)
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_{11}

12. Lumajang Regency (D_{12})

The analysis results of the three models above are also summarized in Table 29. The regencies that able to supply cassava are from sources of S_2 and S_{13}, the same as in Pamekasan regency. From SSM analysis for Lumajang Regency, the shortage can be fulfilled from several regencies including Probolinggo and Pasuruan regencies; and the impossible candidate is Trenggalek Regency with 236 km of distance.

Table 29. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_{12}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan (85) from Malang (117) from Probolinggo (46)	S_2 = from Pasuruan from Malang from Probolinggo	S_{13} = from Ngajuk (216) from Trenggalek(236) from Tulungagung(205)
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_{12}

13. Kediri Regency (D_{13})

The analysis results of the three models above are also summarized in Table 30. The regencies that able to supply cassava are from sources of S_2 and S_{11}.

Table 30. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_{13}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan (156) from Malang (100) from Probolinggo (194)	S_2 = from Pasuruan from Malang from Probolinggo	S_{11} = from Sampang from Sumenep from Bangkalan
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance number from S_i to D_3

From the above analysis, areas that able to fulfill the cassava shortage are from Malang, Pasuruan or Probolinggo Regencies. Those three regencies are selected based on the analysis of three models, NWCM, MC and VAM. The decision makers can choose from the three options based on the best possibility and the risk for the distribution implementation.

14. Bondowoso Regency (D_{14})

The analysis results of the three models above are also summarized in Table 31. The regencies that able to supply cassava are from sources of S_2 and S_{13}.

Table 31. Stepping Stone Analysis (the Analysis of Post-Optimization), for D_{14}

No	NWCM Analysis	MC Analysis	VAM Analysis
1	S_2 = from Pasuruan (131) from Malang (186) from Probolinggo (92)	S_2 = from Pasuruan from Malang from Probolinggo	S_{13} = from Ngajuk (362) from Trenggalek(328) from Tulungagung(297)
2	Initial solution= 177001100	Initial solution= 177001100	Initial solution= 0.00

Description: (…) the distance from S_i to D_{14}

The implementation of recommendation need to consider the choice of the least shipping cost since the optimum indicator is minimization cost (MC) by considering the requirement of other regencies that need to be fulfilled.

F.6. ANALYSIS ON THE RESULTED DISTRIBUTION OPTIMIZATION IN AREAS WHICH NOT SUPPOSED TO BE THE DESTINATION OF CASSAVA DISTRIBUTION

MODI is the continuation of SSM. These two analyses often called post-optimization analysis (Dwi Hayu A. and Yus Endra R, 2004:125). The advantage of MODI compare to the predecessor analyses, especially SSM, is the determination of empty cell (invisible area/regency) which cost effective if conducted with the certain and appropriate procedures.

In addition, MODI can achieve the optimal solution more quickly. If identifying every stepping-stone line to calculate the change in cost per unit in every new cell (regency) is the biggest obstacle in SSM method, this calculation of cost per unit can be done easily using MODI analysis.

Optimization by means of cassava distribution from excess production area to shortage area can be done using MODI; however this analysis does not show which area that should not be the destination for cassava distribution. MODI is the final model that can provide accurate information on optimal analysis, thus, MODI is the final iteration calculation. The analysis results are mathematic consideration in cassava distribution in entire East Java region, however, other considerations such as the possibility of bad roads, demonstration or carnival events and so on should be considered in the implementation of cassava distribution.

Following are the interpretation of MODI analysis' results from each NWCM, MC and VAM models:

1. MODI from NWCM
   a) For Sidoarjo Regency (D_1), the demand between initial solution (IS) and optimum solution (OS) have different results. IS recommended that D_1 can be supplied from S_1 (Pasuruan, Bangkalan, Malang and Probolinggo regencies). While, OS recommended that D_1 can be supplied from S_2 (Pasuruan, malang and Probolinggo regencies). (Note: IS is the result of NWCM analysis and OS is the result of MODI analysis).
   b) For Jember (D_2), Gresik (D_3), Banyuwangi (D_4), Jombang (D_5) and Mojokerto (D_6) regencies, the demand can be supplied from S_1 either in IS or OS condition.
   c) Lamongan regency (D_7) can be supplied from two direction, S_1 and S_2 in IS condition, whereas in OS is from S_1.
   d) Bojonegoro regency (D_8) can be supplied from two direction, S_1 and S_2 either from IS or OS.
   e) Blitar (D_9), Situbondo (D_{10}), Pamekasan (D_{11}), Lumajang (D_{12}), Kediri (D_{13}), and Bondowoso (D_{14}) can be supplied from two directions, S_1 and S_2 either from the calculation of IS and OS.
2. MODI from MC
   a) Sidoarjo regency (D_1) can be supplied by S_1 either from the calculation of IS or OS.
   b) Jember (D_2), Gresik (D_3), Banyuwangi (D_4), Jombang (D_5), Bojonegoro (D_8) and Kediri (D_{13}) regencies – the demand can be supplied from S_1 either from IS or OS.

c) Mojokerto (D_6), Lamongan (D_7), Blitar (D_9), Situbondo (D_{10}), Pamekasan (D_{11}), Lumajang (D_{12}) and Bondowoso (D_{14}) can be supplied from S_2 either from IS or OS calculation. The final decision on these choices will depend on the manager (top leader).

3. MODI from VAM
   a) Sidoarjo regency (D_1) can be supplied from S_{14} (Probolinggo) either in IS or OS calculations.
   b) Jember (D_2), Gresik (D_3), Banyuwangi (D_4), Jombang (D_5) regencies, the demand can be supplied from S_{10} (Probolinggo) in IS condition, except for Jember (D_2) and Gresik (D_3) the demand also can be supplied from S_{13} (Nganjuk, Trenggalek or Tulungagung). Whereas, on OS condition, Jember (D_2) can be supplied from S_{10} (Probolinggo) and Gresik (D_3), Banyuwangi (D_4), Jombang (D_5) can be supplied from S_{11} (Sampang, Sumenep, and Bangkalan).
   c) Mojokerto (D_6) and Situbondo (D_{10}) can be supplied from S_{14} (Probolinggo) in IS condition, whilst in OS condition, can be supplied from S_{13} (Nganjuk, Trenggalek and Tulungagung).
   d) Lamongan (D_7), Bojonegoro (D_8) and Blitar (D_9) can be supplied from S_{12} (Probolinggo and Pasuruan) either in IS or OS condition.
   e) Pamekasan (D_{11}), Lumajang (D_{12}) and Bondowoso (D_{14}) can be supplied from S_{13} (Nganjuk, Trenggalek and Tulungagung) either in IS or OS condition.
   f) Kediri Regency (D_{13}) can be supplied from S_{11} (Sampang, Sumenep and Bangkalan) either in IS or OS condition.

   If in the implementation of cassava distribution in MODI analysis is relatively less supportive, the decision maker can choose other alternatives that relevant either from NWCM, MC or VAM analyses.

F.7. ANALYSIS ON THE DISTRIBUTION OPTIMIZATION IN ORDER TO FIND SOLUTION FOR INTER-AREA BALANCES

This degeneracy method is used to answer the analysis of the resulted optimization distribution that should not be the destination for cassava distribution. Technically, the degeneration of transportation problem has gain significant attention since the degenerate solution resulting in inability to arrange the development of all non-basic cells (regencies) to become basic cell.

The degeneration occurs if the proper answer of initial basic is load less then (m+n-1) basic variable $x_{ij} > 0$. This situation happens in determining early basic answer or in the iteration process to determine the next basic.

The first event happened when the stocks and the needs are both depleted in the determination of the first early answer. Therefore, we had to discontinue the determination of the next answer according to the steps in northwest method. The second event also arises because of the same reason when the stocks and the needs are both depleted.

Result of Degeneration Method analysis can be seen on the result of MC method analysis since the optimum solution is distribution with transportation-cost minimization. The real example of recommendation that should not be selected is the one from MODI analysis. The recommendation states that in the implementation of distribution to Kediri regency, it can be supplied from S_{11} consisting of Sampang, Sumenep and Bangkalan regencies, either in initial solution (IS) or optimum solution (OS) conditions. It does not mean that the analysis result is bad, but the recommendation is the last option and there exist other optimum recommendations for cassava distribution to fulfill the requirement of the shortage areas.

G. CONCLUSION

Based on the results of data analysis using ABQM program, it can be discussed as follow:

1. The optimal level of cassava distribution from the excess production area (excess supply) to the shortage area (excess demand) using northwest corner method (NWCM) resulted in following recommendations:
   a) Destination regencies of 1 – 7, namely Sidoarjo (D_1), Jember (D_2), Gresik (D_3), Banyuwangi (D_4), Jombang (D_5), Mojokerto (D_6) and Lamongan (D_7) showed optimal condition. Means that the nearest regency from these regencies have been able to fulfill the shortage in six regencies mentioned above.
   b) Destination regencies of 8-14, namely Bojonegoro (D_8), Blitar (D_9), Situbondo (D_{10}), Pamekasan (D_{11}), Lumajang (D_{12}), Kediri (D_{13}), and Bondowoso (D_{14}) are regencies that unable to be fulfilled from S_1. The optimum condition in destination regencies of 8 – 14 can be fulfilled from destination regency S_2 (Probolinggo, Pasuruan and Malang regencies). Only for Lumajang regency (D_7), the variation of its fulfillment can be done from the first destination regency (S_1) and/or from the second destination regency (S_2).
2. The level of optimization distribution by means of least cost minimization as a basis for consideration in implementing cassava distribution in a region using minimization cost method (MCM) shows a good consideration, namely:
   a) Sidoarjo regency with a minimum shipping fee will be fulfilled from regency S_2 consisting of Probolinggo, Pasuruan and Malang regencies.
   b) The destination regencies of 2 – 5, namely Jember (D_2), Gresik (D_3), Banyuwangi (D_4), Jombang (D_5), shows optimum condition. It means that the nearest regencies from these areas have been able to fulfill the shortage in these six regencies. Those destination regencies have been optimally fulfilled from origin regency S_1 consisting of Pasuruan, Bangkalan, Malang and Probolinggo regencies. S_1 also supply Bojonegoro (D_8) and Kediri (D_{13}) regencies.
   c) The destination regencies of 6,7,9-12 and 14 which are Mojokerto (D_6), Lamongan (D_7), Blitar (D_9), Situbondo (D_{10}), Pamekasan (D_{11}), Lumajang (D_{12}), and Bondowoso (D_{14}) are regencies that have been fulfilled from S_2. The optimum condition is reached by the fulfillment from S_2 (Probolinggo, Pasuruan and Malang regencies).

d) From those two alternative policies, managers are faced with several choices. The decision to be taken will depend on the smallest possible risk they faced in the implementation of distribution.

3. The result of optimization description by means of preventing the possibility of overlooking the potential areas for cassava distribution using Vogel's Approximation Method (VAM) can be described as follow:
   a) Sidoarjo regency (D_1) with a minimum shipping fee will be fulfilled from regency S_{14} namely Bondowoso Regency.
   b) The destination regencies of 2 – 3 (Jember (D_2) and Gresik (D_3) regencies) are optimally fulfilled from origin-district Probolinggo (S_{10}) – the optimal condition is shown by sources = 0.00. However, Gresik and Jember must be subsidized from other regencies which are Nganjuk, Trenggalek and Tulungagung regencies (S_{13}). S_{13} also supplies Pamekasan (D_{11}), Lumajang (D_{12}) and Bondowoso (D_{14}) regencies.
   c) The destination regencies of Banyuwangi (D_4) and Jombang (D_5) have been optimally fulfilled from origin regency Probolinggo (S_{10}) – the optimal condition is shown by sources = 0.00 (see Table 9). In other words, the optimal condition in the origin areas of Probolinggo (S_{10}) has been able to supply the nearest regencies D_2 – D_5 which are Jember, Gresik, Banyuwangi and Jombang regencies.
   d) Another alternative policy based on the Vogel model is that destination area D_6 which is Mojokerto has been fulfilled from Probolinggo regency (S_{14}). Therefore, Probolinggo regency has three alternative areas for cassava distribution which are Mojokerto, Sidoarjo (D_1) and SItubondo (D_{10}) with the shipment of 153,914 ton, 86,874 ton and 53,831 ton, respectively. And the availability is 165,565 ton. From these three alternatives, the best option will be the shipment from Probolinggo regency (S_{14}) to Sidoarjo regency (D_1) since the remaining cassava in Probolinggo regency is less (sources=11,651 ton) compare to Mojokerto (D_6) and Situbondo (D_{10}) with the remaining cassava of 78,691 ton and 111,734 ton, respectively.
   e) The destination regencies of 7, 8 and 9, which are Lamongan (D_7), Bojonegoro (D_8) and Blitar (D_9), are fulfilled from S_{12} areas which are Probolinggo and Pasuruan.
   f) The destination regency that has shown optimal condition is D_{13} which is Kediri Regency and supplied by regencies S_{11} consisting of Sampang, Sumenep and Bangkalan regencies. (Note: Number 1 – 3 known as special transportation models)
4. The optimization in order to look for an inter-regional balance solution using Transshipment Method (TM) analysis, which is a general model of transportation that divided into three specific models, NWCM, MC and Vogel. A balance condition will be reached if the distribution policy is to Jember (D_2), Gresik (D_3), Banyuwangi (D_4), Jombang (D_5), Blitar (D_9), Situbondo (D_{10}), Lumajang (D_{12}), Kediri (D_{13}), and Bondowoso (D_{14}).
5. The optimization of cassava distribution in desirable 'potential' areas (possible candidates) that also will detect "impossible" candidate areas to distribute

cassava using analysis of stepping-stone method (SSM) also shows optimal results with the same optimum variation as before. Following is the results of the analysis (the analysis often referred as the post-optimization analysis):

No	Possible Candidates	Impossible Candidates
1	Sidoarjo – Pasuruan	Sidoarjo – Probolinggo
2	Jember – Probolinggo	Jember – Trenggalek
3	Gresik – Bangkalan	Gresik – Trenggalek
4	Banyuwangi – Probolinggo	Banyuwangi – Malang
5	Jombang – Pasuruan	Jombang – Probolinggo
6	Mojokerto – Pasuruan	Mojokerto – Probolinggo
7	Blitar – Malang	Blitar – Probolinggo
8	Bojonegoro – Pasuruan	Bojonegoro – Probolinggo
9	Blitar – Malang	Blitar – Probolinggo
10	Situbondo – Probolinggo	Situbondo – Malang
11	Pamekasan – Pasuruan	Pamekasan – Trenggalek
12	Lumajang – Probolinggo	Lumajang – Trenggalek
13	Kediri – Malang	Kediri – Probolinggo
14	Bondowoso – Probolinggo	Bondowoso – Nganjuk

6. Optimization analysis by means of cassava distribution from the excess production areas to the shortage areas using analysis of Modified Distribution Method (MODI), but it does not show which area that should not be the destination for cassava distribution (Note: MODI is the continuation of SSM analysis that often referred as the post-optimization analysis), is also shows the same optimal variation as in number 5.
7. The same result as number 5 also shown in the optimization of cassava distribution if the stocks and the needs are both depleted using the Degeneracy Method (DM).

H. SUGGESTIONS

Based on the research results and discussion, it can be recommended as follow:

1. In the table of possible and impossible condition shown in the conclusion above, the recommendations offered are based on the result of SSM and MODI, which are post-optimization transportation analysis. SSM and MODI are final models that can provide accurate information in an optimal analysis. Therefore, SSM and MODI are the final iteration calculation. The analysis results are mathematic consideration in cassava distribution in entire East Java region, however, other considerations such as the possibility of bad roads, demonstration or carnival events and so on should be considered in the implementation of cassava distribution.
2. Since the cassava distribution can be done optimally and balanced, a question arose “what should be done so that this balance and cassava’s existence can be adopted by society in the targeted areas”? The answer is by creating products

diversification in order that cassava consumption can be increased from 8% to 16%, 24% and so on. If it can be achieved, it can support food security, and at least, the speed of the dependency on rice can be restrained.

3. The products diversification efforts can be done in the second year of this research. This cassava empowerment is targeted to the group of fast food producers that produced fried cassava or other forms of food made from cassava.
4. The attainment of optimal condition with a guaranteed balance is the indication that cassava shortage can be better fulfilled (supplied); however, the demand will remain better if there is a positive response to it. The responsiveness of demand is through the implementation of recommendation for products diversification.
5. Other opportunities that can be used as the alternative for product diversification is by producing various fast food made from cassava, such as cake, tart, flour, chips, biotanol tapioca, or else.
6. Further studies are needed to answer a question on what should be done after the optimum condition is reached. It is necessary to conduct action research to:
   a) Detect many constraints faced by food manufacturers in form of "fried food" in creating non-rice food alternatives.
   b) Find priorities of training scheme in order to construct a scenario of post-intervention based on poling.
   c) Carry out evaluation and minimization of constraints faced by producers by intervention of technology, production management stimulus.
   d) Implant cassava-based food paradigm as early as possible to the targeted groups through cassava demonstration; and
   e) Conduct response analysis of post-demonstration target group through the product diversification from cassava.

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